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Application of data-driven modeling to geochemical data: estimating the degree of mantle melting using the major element composition of basalts

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Data-driven approaches that objectively determine models from data using machine learning techniques are a powerful methodology for exploring and interpreting various geochemical datasets, both natural and experimental. We present a simple linear equation to estimate the degree of melting of the upper mantle using the major element composition of basalts, derived from a data-driven analysis of compiled results of high-pressure mantle melting experiments. We determined the optimal equation and its coefficients using a model selection approach. In the model selection approach in this study, we evaluated various candidate equations based on three statistical criteria: leave-one-out cross-validation error, AIC, and BIC. Based on the model selection analysis, we found that the degree of mantle melting can be predicted using only the concentrations of three major elements: SiO_2, FeO^* (total iron as FeO), and MgO [1]. The proposed equation can be applied to calculate the melting of spinel lherzolite to harzburgite source mantle under both anhydrous and hydrous conditions and can be applied to both batch and fractional melting. This equation can be used to determine and discuss the degrees of melting of various natural systems from MORB to subduction zones.

[1] Ueki et al. (2025) *PEPI*, 107464